# Evaluation of Ultrasound Analysis of Body Composition in Beef Cattle

An Honors Thesis

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## Introduction

Ultrasound analysis of body composition has become an increasingly important tool for today's livestock producer. It provides valuable information that would otherwise only be obtained upon slaughter of the animal. With ultrasound analysis, improvement of carcass traits can now be part of a producer's breeding goals. Those animals with high carcass merit can now be used to meet market demands. Ultrasound provides an indirect source of additional information for the calculation of genetic merit. Certification of technicians for use of ultrasound to measure fat thickness, ribeye area, and intra-muscular fat percentage is now possible through the Beef Improvement Federation, and many new companies have begun on-farm measurements for producers.

As ultrasound use has increased, more attention has been given to the accuracy of ultrasound measurements. If ultrasound is to be effective as an indicator of genetic merit, it must provide a true picture of the animal's body composition. The purpose of this study was to compare ultrasound measurements of longissimus muscle area and backfat thickness with the corresponding post-slaughter carcass measurements.

## Literature Review

Ultrasound analysis of livestock was first introduced in the 1950's (Temple et al., 1956 ; Hazel and Kline, 1959).

These early ultrasound machines were crude at best and were very labor intensive and cumbersome. However, with the advent of real-time ultrasound, this technology has become much more practical (Bullock et al., 1991). Real-time ultrasound uses high frequency sound to map tissue boundaries. Reflected soundwaves are projected on a monitor in real-time, with tissue boundaries indicated by shades of gray. The result is a movie-like effect that provides a cut-away view of the animal's internal structures. Technical improvements in real-time ultrasound have greatly increased resolution of the ultrasonic image, resulting in improved accuracy over the past decade (Herring et al., 1994). Research has shown correlations between ultrasound and carcass measurements as high as .90 for backfat and .87 for longissimus muscle area (Robinson et al., 1992). Other studies have yielded similar high correlations (Smith et al., 1992; Herring et al., 1994; Williams et al. 1997). In all of these studies live ultrasound measurements have proven to be both accurate and effective tools for analysis of body composition. Furthermore, Herring et al. (1992) asserted that ultrasound analysis is a better indicator of genetic merit for body composition than are actual carcass measurements due to variation and inconsistency in the slaughter process. For example, Herring et al. (1992) observed that use of a hide puller during the hide removal process removed excess fat, especially from the 12-13th rib site. It is at this site that ultrasound measurements are taken. Therefore, ultrasound measurements are thought to

provide a more accurate measurement of actual backfat than are measurements taken on the carcass following slaughter.

## Materials and Methods

### *General*

A total of 1,189 bulls and heifers were used for this study. These cattle were part of a continuing research study by Dr. M. E. Davis concerning divergent selection for the hormone insulin-like growth factor I (IGF-I) and its affects on growth and body composition. The experiment was begun in 1989 at the Eastern Ohio Resource Development Center, Belle Valley, OH. This experiment consisted of approximately 100 spring-calving cows (50 high IGF-I and 50 low IGF-I line cows) and 100 fall-calving cows (50 high IGF-I and 50 low IGF-I line cows).

Spring-born calves were reared by their dams and weaned at approximately 7 months of age. After a 2 week adjustment period, the calves entered a 140-day postweaning trial to monitor the effects of IGF-I on growth and body composition. Average age of spring-born calves at the beginning of the postweaning trial period was 235 days.

Fall-born calves were weaned at approximately 140 days of age and then fed a growing diet for 112 days in drylot. The calves then entered the 140 day postweaning trial. Average age of fall-born calves at the beginning of the

postweaning trial was 263 days. The diet fed during both spring and fall trials was a corn, oat, protein supplement, and mineral/vitamin mix. Only those bulls not needed for breeding were slaughtered. Therefore, a total of 242 bulls were used for both ultrasound and carcass analysis (Davis et al., 1995).

Ultrasound measurements were generally taken on day 56 and 140 of the postweaning period. Blood samples for IGF-I determination were taken on day 28, 42, and 56. Measurements of backfat and loineye area were made between the 12th and 13th rib in accordance with hanging carcass measurements taken at the same site. After removal of excess hair and dirt, vegetable oil was applied to the site to form a proper medium for soundwaves to enter the body. The ultrasound transducer was then positioned laterally over the site to obtain ultrasonic images of the backfat and loin. The ultrasound machine used from 1990 to 1994 of the study was an Aloka 210 with a 12 cm 3.5 MHz probe. In 1995, an Aloka 500V with a 17 cm 3.5 MHz probe was used. All ultrasound machines and probes were distributed by Corometrics Medical Systems, Wallingford, CT. Images were then recorded to an 8 mm tape and analyzed using the Animorph ultrasound image interpretation software. (distributed by Animal Ultrasound Services, NY). Backfat depth at the 3/4 point and loineye area were recorded on each animal. At the end of the 140 day test, bulls not kept for breeding purposes were taken to Falter's Packing Co., Columbus, OH for slaughter. Hanging carcass measurements of backfat and loineye area were

compiled by trained faculty of the OSU Department of Animal Sciences.

*Statistical Analysis*

Residual correlations between ultrasound measurements and carcass measurements were calculated using GLM procedures in SAS statistical software located on the IBM 3090 mainframe computer. The statistical model included fixed effects for year-line-season and age of dam. A random effect of sire of calf nested within year-line-season was also included. An additional fixed effect of sex of calf was added to the model in later calculations of correlations involving both bulls and heifers. The model also included a covariate for age of calf at the beginning of the postweaning test. Correlations were obtained between day 56 ultrasound backfat (ULTRAFT1) and carcass backfat (FAT), day 140 ultrasound backfat (ULTRAFT2) and carcass backfat, day 56 ultrasound loineye area (ULTRALA1) and carcass loineye area (RIBEYE), and day 140 ultrasound loineye area (ULTRALA2) and carcass loineye area. Additional correlations were obtained after removal of any data with abnormal values (i.e., ULTRAFT1 > ULTRAFT2). Year and season effects on correlations were examined over the 6 years of the study. Lastly, as a supplement to the IGF-I selection experiment, differences between means of high-line and low-line cattle and between means of spring and fall cattle were also determined. These differences were based on data obtained from ultrasound scans. Unlike

previous studies reported in the literature, no carcass measurement multiplication factors were used to correct for error due to shrinkage (Robinson et al., 1992).

**Results and Discussion**

Means for ultrasound and carcass measurements are listed in Table 1. Correlations between ultrasound and carcass measurements and levels of significance are presented in Tables 2 and 2a. Correlations by year and season are presented in Table 3. All correlations were far below expectations. When data from all years and seasons were combined, residual correlations for ultrasound fat and carcass fat

ranged from .52 for ULTRAFT1 and FAT to .48 for ULTRAFT2 and FAT. Residual correlation for ultrasound loineye area and carcass loineye area ranged from .53 for ULTRALA1 and RIBEYE to .33 for ULTRALA2 and RIBEYE. Correlations for backfat by year and season ranged from .89 for ULTRAFT1 and FAT in Spring, 1993 to .08 for ULTRAFT2 and FAT in Spring, 1994. Correlations for loineye area by year and season ranged from .78 for ULTRALA1 and RIBEYE in Fall, 1994 to -.61 for ULTRALA2 and RIBEYE in Fall, 1993. Furthermore, wide variation in correlations existed from season to season and from year to year. Moderate to high accuracy was obtained in some years, yet low accuracy appeared in other years. In total, ultrasound data from this study proved much less accurate than anticipated.

As stated earlier, other studies concerning accuracy of ultrasound have yielded much more positive results. Herring et al. (1994) noted that error in analysis can occur at two key points during ultrasound procedures. The first is during the actual imaging of the live animal. In the early phase of this study, the transducer was too small to measure the longissimus muscle with one frame. Rather, images were taken of the upper and lower portions of the muscle. These two images were then joined to produce a single picture. This procedure introduces error into the analysis. Later measurements were taken using a larger transducer capable of capturing the entire longissimus muscle in one frame. Furthermore, technician skill and expertise in operation of the ultrasound machine can introduce additional error. Herring et al. (1994) showed that ultrasound is a valuable tool. However, a technician's ability to produce an accurate image is variable and can introduce tremendous error. The second point of error can occur during the interpretation of the stored image. A technician uses the differences in shades of gray that occur due to different tissue densities to determine where to measure backfat and loineye area. A computer software package (Animorph) allows the technician to use a mouse to outline the loineye image and measure backfat. The computer program then calculates the loineye area and depth of fat from the cursors placed on the screen. Calculation of both measurements is subjective in that images may be unclear or of poor quality. Boundaries between muscle and bone or muscle and fat may be misinterpreted by the

technician. Therefore, error is once again introduced. In this study, a combination of many technicians and many levels of ability contributed to a relatively low accuracy of measurement.

A third source of variation in this study may have come from processing at slaughter. It has been noted in previous studies that the use of a hide puller at slaughter will cause an overestimation of backfat by ultrasound measurements (Herring et al., 1994). As was stated earlier, Herring et al. (1994) concluded that ultrasound measurements were more accurate than carcass measurements due to removal of backfat during hide removal. Excessive fat removal may have caused an overestimation of backfat and poor accuracy of measurements in this study. However, the importance of this factor in our study is not known. Other studies have also included adjustment factors for shrinkage of the loineye muscle in their calculations. Robinson et al. (1992) applied a standard multiplication factor of 1.17 to all carcass loineye area measurements. This adjustment was not used in our study. Lastly, there was variation between slaughter age and final ultrasound age (day 140). Bulls used for the carcass study were slaughtered within approximately two weeks of the final ultrasound scan. Continued growth over this time span may have contributed to some of the differences between the ultrasound and carcass measurements.

*Selection Line and Calving Season Results*

Differences in high-line/low-line and spring/fall cattle were also analyzed. These differences are shown in Tables 4 and 4a. In all cases, high line cattle were fatter and had larger loineye areas at the time of the ultrasound scan. However, in no case were these differences statistically significant ($P > .05$). Additionally, in all cases, spring cattle were fatter and had larger loineye areas at the time of scan. These differences were significant ($P < .05$) and can most likely be attributed to differences in management of spring and fall calves. Spring calves were weaned at 7 months of age and began the postweaning trial within approximately 2 wk of weaning. Fall calves were weaned early at 140 days of age, and then were fed a growing diet formulated to yield gains of approximately .9 kg per day (Davis et al., 1995). After the growing phase of 112 days, fall calves entered the 140-day postweaning period. Early weaning and a slower growing phase for the fall-born calves may explain these differences.

**Implications**

Previous studies have shown ultrasound to be a valuable tool for prediction of carcass genetic merit. This study clearly shows the importance of having experienced, trained ultrasound technicians. It is very important that technicians be well-trained in basic operation of the

ultrasound machine, as well as is in interpretation of the stored ultrasound images. Furthermore, it is important that technicians maintain their skills through constant practice and accreditation. These results show that major sources of inaccuracy can occur at many steps along the ultrasound process. It is of the utmost importance that technicians be thoroughly trained at every step.

Table 1. Means and standard deviations for ultrasound measurements and carcass measurements.

| | Mean | Standard Deviations |
|---|---|---|
| ULTRAFT1[a], mm | 6.58 | .12 |
| ULTRAFT2[b], mm | 9.59 | .17 |
| ULTRALA1[c], $cm^2$ | 58.21 | 7.10 |
| ULTRALA2[d], $cm^2$ | 72.34 | 8.26 |
| FAT[e], mm | 9.13 | 2.74 |
| RIBEYE[f], $cm^2$ | 78.73 | 7.03 |

[a] ULTRAFT1 = day 56 ultrasound fat measurement.
[b] ULTRAFT2 = day 140 ultrasound fat measurement.
[c] ULTRALA1 = day 56 ultrasound loineye area measurement.
[d] ULTRALA2 = day 140 ultrasound loineye area measurement.
[e] FAT = carcass fat measurement.
[f] RIBEYE = carcass loineye area measurement.

Table 2. Residual correlations between ultrasound measurements and carcass measurements (levels of significance[a] in parentheses)

| TRAIT[b] | FAT | RIBEYE |
|---|---|---|
| ULTRAFT1 | .52 (.0001) | |
| ULTRAFT2 | .48 (.0001) | |
| ULTRALA1 | | .53 (.0001) |
| ULTRALA2 | | .33 (.0001) |

[a] Correlations were significant if $P < .05$.
[b] See text for definitions of abbreviations.

Table 2a. Residual correlations between ultrasound measurements and carcass measurement with the removal of abnormal data (levels of significance[a] in parentheses)

| TRAIT[b] | FAT | RIBEYE |
|---|---|---|
| ULTRAFT1 | .47 (.0001) | |
| ULTRAFT2 | .46 (.0001) | |
| ULTRALA1 | | .50 (.0001) |
| ULTRALA2 | | .40 (.0001) |

[a] Correlations were signigicant if $P < .05$.
[b] See text for definitions of abbreviations.

Table 3. Residual correlations between ultrasound measurements and carcass measurements by year and season and number of animals scanned, n (levels of significance[a] in parentheses)

**ULTRAFT1 and FAT**

| 1990 | | 1991 | | 1992 | |
|---|---|---|---|---|---|
| Spring | Fall | Spring | Fall | Spring | Fall |
| .83 | - | .53 | - | .57 | .41 |
| (.001) | - | (.02) | - | (.04) | (.03) |
| n = 19 | | n = 31 | | n = 27 | n = 25 |

| 1993 | | 1994 | | 1995 | |
|---|---|---|---|---|---|
| Spring | Fall | Spring | Fall | Spring | Fall |
| .89 | - | .13 | .54 | .63 | .23 |
| (.0002) | - | (.62) | (.03) | (.003) | (.47) |
| n = 25 | | n = 30 | n = 30 | n = 31 | n = 24 |

**ULTRAFT2 and FAT**

| 1990 | | 1991 | | 1992 | |
|---|---|---|---|---|---|
| Spring | Fall | Spring | Fall | Spring | Fall |
| .42 | - | - | .56 | .85 | .18 |
| (.19) | - | - | (.02) | (.0002) | (.58) |
| n = 19 | | | n = 30 | n = 26 | n = 25 |

| 1993 | | 1994 | | 1995 | |
|---|---|---|---|---|---|
| Spring | Fall | Spring | Fall | Spring | Fall |
| .38 | .09 | .08 | .48 | .72 | .43 |
| (.20) | (.82) | (.74) | (.08) | (.0003) | (.14) |
| n = 27 | n = 18 | n = 30 | n = 28 | n = 31 | n = 25 |

Table 3. (cont...)

**ULTRALA1 and RIBEYE**

| 1990 | | 1991 | | 1992 | |
|---|---|---|---|---|---|
| Spring | Fall | Spring | Fall | Spring | Fall |
| .62 | - | .45 | - | .71 | .77 |
| (.04) | - | (.05) | - | (.006) | (.003) |
| n = 19 | | n = 31 | | n = 27 | n = 25 |

| 1993 | | 1994 | | 1995 | |
|---|---|---|---|---|---|
| Spring | Fall | Spring | Fall | Spring | Fall |
| .24 | - | -.02 | .78 | .60 | .65 |
| (.47) | - | (.92) | (.0004) | (.004) | (.02) |
| n = 25 | | n = 30 | n = 30 | n = 31 | n = 24 |

**ULTRALA2 and RIBEYE**

| 1990 | | 1991 | | 1992 | |
|---|---|---|---|---|---|
| Spring | Fall | Spring | Fall | Spring | Fall |
| .61 | - | - | .69 | .68 | .47 |
| (.04) | - | - | (.001) | (.01) | (.12) |
| n = 19 | | | n = 30 | n = 26 | n = 25 |

| 1993 | | 1994 | | 1995 | |
|---|---|---|---|---|---|
| Spring | Fall | Spring | Fall | Spring | Fall |
| .28 | -.61 | -.17 | .31 | .12 | .35 |
| (.40) | (.11) | (.51) | (.27) | (.60) | (.24) |
| n = 25 | n = 18 | n = 30 | n = 28 | n = 31 | n = 25 |

[a] Correlations are significant if $P < .05$.

Table 4. Differences between high line and low IGF-I line cattle (with levels of significance) based on ultrasound measurements[a]

| | Difference (high line - low line) | Level of Significance |
|---|---|---|
| ULTRAFT1 | .0056[b] | .28 |
| ULTRAFT2 | .0036[b] | .66 |
| ULTRALA1 | .0671[c] | .52 |
| ULTRALA2 | .0896[c] | .41 |

[a] Differences are significant if $P < .05$
[b] Differences are given in millimeters.
[c] Differences are given in square centimeters.

Table 4a. Differences between spring and fall cattle (with levels of significance) based on ultrasound measurements[a]

| | Difference (spring - fall) | Level of Significance |
|---|---|---|
| ULTRAFT1 | .0642[b] | .0001 |
| ULTRAFT2 | .0399[b] | .0010 |
| ULTRALA1 | 1.3913[c] | .0001 |
| ULTRALA2 | .8545[c] | .0001 |

[a] Differences are significant if $P < .05$.
[b] Differences are given in millimeters.
[c] Differences are given in square centimeters.

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